

Civil Services of Bengal, Madras, and Bombay, involving questions amounting to millions of pounds sterling between the Government and the members of those distinguished Services, their widows and children. The last of these laborious undertakings, for which, from his knowledge of India and the circumstances of the cases, he was so pre-eminently qualified, had been but very recently completed when he died.

In 1872 he was appointed Assistant Secretary in the Finance Department of the India Office, and remained in that appointment to the end of his long life of zealous, indefatigable, eminently useful, and well-nigh unique service. He may most truly be said to have died in harness.

General Hannington's scholarly and scientific attainments were great and varied. To unusual mathematical acquirements as applied to astronomy and navigation were united actuarial abilities of a very high order. He was a good scholar in Oriental languages, more especially in Bengalee. By practice during a long series of years in the performance of his judicial duties he had made himself an expert shorthand writer. The value of Thoman's arithmometer was very early recognised by him, and he was the first to avail himself of it in the calculation of life contingencies. To his intelligence and mathematical power is due the invention of a very ingenious and useful slide-rule. His best known and largest work is a table of Haversines, natural and logarithmic, used in computing distances for the "Nautical Almanac." It was printed by the Admiralty, and is a fitting and enduring monument of his patient and persevering industry.

General Hannington was a truly pious, simple-minded, Christian gentleman, trusted, respected, and beloved by all who knew him.

He was elected a Fellow of this Society, 1875, March 12.

JOHN HARTNUP was born at Hurst Green, in Sussex, on January 7, 1806. His first astronomical work of importance was performed at Mr., afterwards Lord, Wrottesley's private observatory at Blackheath, where he was employed as assistant. The part taken by Mr. Hartnup in the observations of the Wrottesley Catalogue of Stars is referred to in the Society's *Monthly Notices*, No. 1, Vol. iv. He was subsequently engaged as a supernumerary at the Royal Observatory, Greenwich, and afterwards became Assistant Secretary to the Royal Astronomical Society. The results of a series of observations made by Mr. Hartnup with a sextant and pocket chronometer for determining the latitude and longitude of the Society's apartments at Somerset House are given in the *Monthly Notices*, No. 2, Vol. vi. In November, 1843, Mr. Hartnup was appointed Director of the Liverpool Observatory. A few words as to the objects of this establishment may perhaps not be out of place.

Between the years 1834 and 1838 urgent requests were

frequently made by officers in the Royal Navy and in the Mercantile Marine, astronomers, and various scientific men, for the establishment of a Nautical Observatory at Liverpool. In 1837 a memorial was presented to the Corporation by the British Association for the Advancement of Science. The memorial drew attention to the fact that no one was responsible for giving correct time to the port; that chronometer-makers could not be trusted to make the necessary astronomical observations themselves, as they had been known to differ from each other as much as two minutes in the Greenwich mean time, and that such errors must be dangerous to vessels leaving the port. A committee of the Town Council appointed to take the matter into consideration reported that the means for giving accurate time to the port did not exist, and that chronometers were sent to sea with various sources of error. The chief objects, then, of the establishment of an observatory in Liverpool were the communication of accurate time to the port and the rating of chronometers.

The great differences frequently found to exist between the sea and shore rates of chronometers was a subject which appeared enveloped in mystery. Mr. Hartnup found change of temperature to be the chief cause of these changes of rate. No. 8, vol. ix., of the Society's *Monthly Notices* contains a paper by Mr. Hartnup on an improved form of compensation balance. This balance is practically perfect in its action, as chronometers to which it is applied maintain very nearly the same rate in extremes of heat and cold and in the middle temperature. It is, however, not nearly so strong as the ordinary form, is much more difficult to make and also to adjust, and is liable to be injured by unskilful hands. Although the architect availed himself of the advice of the best authorities of that day on the construction of the building, no provision was at first made for controlling the temperature in the chronometer-room at the Liverpool Observatory. Limited arrangements for this purpose were afterwards made at Mr. Hartnup's request. The Report for 1854 of the British Association for the Advancement of Science contains a paper by Mr. Hartnup on the variation in the rates of chronometers, and tables are given showing the change in the daily rate of each of one hundred chronometers caused by changing the temperature from 40 to 60, from 60 to 80, and from 50 to 80 degrees Fahrenheit. In consequence of Mr. Hartnup's reports on the importance of testing chronometers before they are used at sea the Mersey Docks and Harbour Board extended and improved the arrangements for testing these instruments, and soon after the removal of the Observatory to Bidston, permission was given by the Board to establish a system of testing chronometers in the two extremes and middle temperature to which ships are generally exposed at sea. A careful examination of the results obtained from the tests of upwards of a thousand chronometers in the three definite temperatures of 55, 70, and 85 degrees Fahrenheit showed:—

1. That there was a definite temperature peculiar to each chronometer, in which it went faster than in any other temperature.
2. As the number of degrees above or below the temperature of maximum gaining rate increased, the chronometer lost in a rapidly increasing ratio.
3. Rates calculated on the assumption that the rate changes directly as the square of the number of degrees from the temperature of maximum gaining rate agreed closely with rates obtained from observation.

In his Report for 1872 to the Marine Committee of the Mersey Docks and Harbour Board, Mr. Hartnup gives a formula for calculating the correction due to thermal error, for any temperature of a chronometer whose rate has been determined by observation in the three definite temperatures of 55, 70, and 85 degrees Fahrenheit. An example showing the advantage of applying such corrections to the rates of two chronometers during a voyage from Liverpool to Calcutta is given in No. 2, vol. xxxv., of the Society's *Monthly Notices*. Vol. iii. of the "Dun Echt Observatory Publications," recently issued by the Earl of Crawford and Balcarres, contains a detailed account of the determination of the temperature corrections of the fifty chronometers employed on his expedition to Mauritius for the observation of the Transit of Venus in 1874. These chronometers were tested at the Liverpool Observatory both before and after the expedition, and Mr. Hartnup's formula was used in the calculation of the corrections for thermal error. In 1877 the Directors of the Pacific Steam Navigation Company ordered the chronometers belonging to their ships to be sent to the Liverpool Observatory to be rated. The notices as to the work at the Liverpool Observatory contained in the annual Reports of the Council of the Society show the careful attention given by Mr. Hartnup to the performance of these chronometers and the accuracy with which Greenwich time can be carried on at sea with chronometers of average quality, when their thermal errors are determined at an observatory provided with efficient apparatus for the purpose, and the corrections due to change of temperature are applied to the rates.

The Liverpool Observatory is provided with an equatoreal of great firmness and steadiness, and Mr. Hartnup's early reports show his ability in the use of this instrument. The results of observations of comets and of several of the minor planets were communicated to the Society, and published in the *Monthly Notices*. The chronometric work, however, gradually became heavier. A large number of chronometers were deposited at the Observatory for the purpose of being rated, and Mr. Hartnup considered the investigation of their performance under varying conditions the most important work to which he could devote his energies and the means at his disposal.

An excellent method of controlling clocks by electric currents was first adopted at the Liverpool Observatory. A paper by Mr. Hartnup on this subject is published in the Report for 1857 of the British Association for the Advancement of Science.

Mr. Hartnup resigned the directorship of the Liverpool Observatory in May, 1885. His health had been failing for some time, and on his retirement he took up his residence in London, chiefly with the view of obtaining medical advice. He died suddenly in London on October 20, 1885.

Enough has been said to show the great amount of labour bestowed by Mr. Hartnup on the subject of marine chronometry. The highest authorities have spoken in strong terms of the utility of the work done at the Liverpool Observatory in testing chronometers for the mercantile marine. Sir G. B. Airy, K.C.B., when Astronomer Royal, repeatedly alluded to the importance of this work. Mr. Hartnup was elected a Fellow of the Royal Astronomical Society on February 14, 1845.

WILLIAM LADD was born at Deal in 1815, whence he came to London at the age of 14. Mr. Ladd was well known in scientific and commercial circles for his efforts in aiding research, for during the decade extending from 1860 to 1870 he took a very prominent part in introducing electricity into practical utility. Nor was his interest in this line confined merely to any particular branch of the science, for we find him at one time in correspondence with Prof. Reis, who may be said to have made the earliest efforts towards recording the sound of the human voice transmitted over long distances. A letter is still extant in which Prof. Reis explains to Mr. Ladd his views upon this question, and the partial success that attended his efforts. Mr. Ladd was well known as the constructor of some of the largest induction coils and electrical apparatus, manufactured under his supervision at his premises in Beak Street, Regent Street.

In 1867 Mr. Ladd brought forward a dynamo machine, which in many respects showed a marked improvement on the previous dynamos of Siemens, Varley, and Wilde, and whereby many of the then existing difficulties in the way of constructing dynamos for practical and commercial use were removed. Somewhat later, in the year 1878, Mr. Ladd was instrumental in introducing into this country the Wallace-Farmer system of electric lighting from America, where it had met with considerable success. The dynamos and arc lamps employed on this system underwent considerable improvement at Mr. Ladd's hands; and one of the earliest installations of electric lighting afforded to the public was made under Mr. Ladd's supervision on the above system at the Liverpool Street terminus of the Great Eastern Railway.

Mr. Ladd was from the time of its formation a director of the Anglo-American Brush Electric Light Corporation (Limited),